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TESTING

After obtaining and splitting the sample, the obvious next step is to conduct the test. Uniform and consistent testing is required to remove variables in the total operation

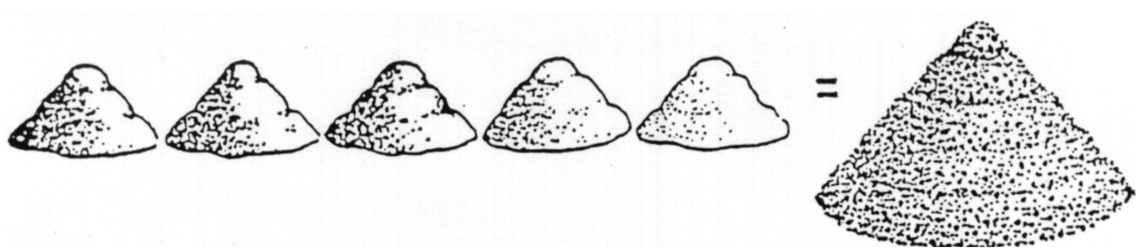
GRADATION

Gradation is the range and relative distribution of particle sizes in the aggregate material

Range refers to the size limits of an aggregate set and to the number of sizes in that set. For example, the sizes in a set may extend from 1 1/2 in. aggregates to 3/8 in. aggregates and include sizes of 1 in., 3/4 in. and 1/2 in. Another set may extend from 2 1/2 in. aggregates to 1/2 in. aggregates with intermediate sizes of 1 1/2 in., 1 in., and 3/4 in.

The relative distribution refers to the percentage of each particle size in the total material. For example, in a given set of aggregates, 16 percent of the total material could be 1 1/2 in. aggregates, 23 percent could be 1 in. aggregates, 14 percent could be 19 mm aggregates and so on.

1 1/2 in. 1 in. 3/4 in. 1/2 in. 3/8 in. Specified Sizes

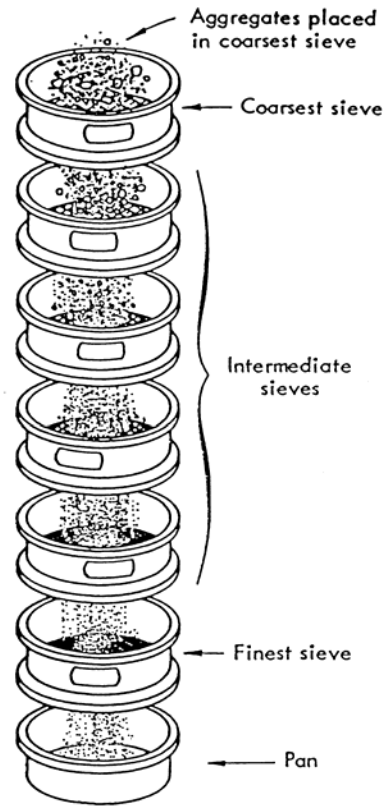


16% 23% 14% 19% 28% 100%

Sets of graded aggregates are referred to by size number with each having a specified range and relative distribution.

The sizes of fine and coarse aggregates used by INDOT and the gradation requirements for each size are found in Section **904**.

Sieving



Gradation is determined by sieving. A sample of the aggregate material being tested is weighed and then passed through a series of sieves as shown on the left.

Sieve sizes correspond to the size of the openings in the mesh. Range is determined by the number and sizes of sieves used. Relative distribution is calculated by weighing the aggregates retained on each sieve.

The coarser sieves are classified according to the size of the openings, in linear inches. Thus, the 1 in. sieve has openings 1 in. square.

Aggregates coarser than the 1 in. sieve are called plus 1 in. material. Aggregates finer than 1 in. sieve are called minus 1 in. material. (Plus (retained) means coarser than; minus means finer than.) To be retained on any sieve, the aggregate must be coarser in every direction than the sieve size.

Decantation

The decantation test determines the amount of material finer than the No. 200 sieve. The test is conducted on both fine and coarse aggregate and is usually done in conjunction with the sieve analysis test. The test is performed according to **AASHTO T 11**, with exceptions noted in Section 904.06.

NOTE: If the total amount passing the No. 200 sieve is required to be determined by the specifications, the amount is determined by a combination of wet and dry sieving, and is represented by the total amount passing the No. 200 sieve following both decantation and dry sieve analysis.

The procedure for decantation is:

1) After the sample has been reduced to the proper size, the sample is thoroughly dried and allowed to cool to room temperature. The weight is recorded on the gradation analysis sheet.

2) The dried material is then placed in a container large enough to hold the sample with adequate wash water and room for agitating the sample.

3) The sample is covered with water.

4) The sample is agitated with a spoon or trowel to separate all particles and to suspend the minus No. 200 material.

5) The wash water is immediately poured or allowed to overflow through a No. 200 sieve. A protector sieve (No. 16) is nested above the No. 200 sieve for protection from the larger particles. Only the wash water (not the sample) is poured on the sieve.

6) The washing and sieving of the wash water is continued until the water runs clear.

7) After the wash water has cleared, the excess water is drained from the sample through the No. 200 sieve. Any residue material is removed from the protector sieve and the No. 200 sieve and placed with the test sample.

8) The washed sample is dried, allowed to cool to room temperature, and weighed. The weight is recorded in the Decant Section of the gradation analysis sheet.

9) The percentage of material finer than a No. 200 sieve is calculated by using the formula:

$$\% \text{ Decant} = \frac{\text{Original Dry Weight - Dry Weight after Decant}}{\text{Original Dry Weight}} \text{ X } 100$$

$$\% \text{ Decant} = \frac{5942.1 - 5885.2}{5942.1} \text{ X } 100 = 0.96\% \approx 1.0\%$$

Decant	Original	Final	Grams Loss	% Loss	% Req.
	5942.1	5885.2	56.9	1.0	

SIEVE ANALYSIS TEST

Sieve analysis is used primarily to determine the particle-size distribution of materials. The results are used to determine compliance of the particle-size distribution with the applicable specification requirements. The test is conducted on both the fine and coarse aggregates and is usually done in conjunction with the decantation test. The test is performed according to **AASHTO T 27**, with exceptions as noted in Section **904.06**.

The procedure for sieve analysis is as follows:

1) The dried (decanted) sample is placed in the top sieve of properly nested sieves. The sieves are nested in sequence with the smallest sieve placed on the pan and stacked by increasing size.

2) The shaking time must be sufficient to ensure that the sample is divided into fractional sizes. The actual shaking time is required to be determined in accordance with **ITM 906**. The standard for establishing the proper shaking time is found in **AASHTO T 27**. The minimum shaking times are as follows.

Coarse Aggregate, Size 9 or larger	5 Minutes
Coarse Aggregate, Smaller than Size 9	10 Minutes
Fine Aggregates	15 Minutes

3) At the conclusion of sieving, the material retained on each sieve is carefully transferred to a pan and weighed. The weight of the material retained on each sieve is recorded on the Gradation Analysis sheet. The weight cannot exceed the allowable amount on each sieve as indicated in Table 1.

NOTE: The larger sieves (above the No. 16) are cleaned with a small trowel or piece of flat metal. The sieves between the No. 16 and No. 50 are cleaned with a wire brush. Sieves smaller than the No. 50 cleaned with a soft bristle brush. Care must be taken not to damage the sieves.

TABLE 1
APPROXIMATED SIEVE OVERLOAD

SCREEN SIZE	STANDARD 15 in. x 23 in.	STANDARD 14 in. x 14 in.	12 in. DIAMETER	8 in. DIAMETER
3 in.	40.5 kg	23.0 kg	12.6 kg	-------------
2 in.	27.0 kg	15.3 kg	8.4 kg	3.6 kg
1-1/2 in.	20.2 kg	11.5 kg	6.3 kg	2.7 kg
1 in.	13.5 kg	7.7 kg	4.2 kg	1.8 kg
3/4 in.	10.2 kg	5.8 kg	3.2 kg	1.4 kg
1/2 in.	6.7 kg	3.8 kg	2.1 kg	890 g
3/8 in.	5.1 kg	2.9 kg	1.6 kg	670 g
No. 4	2.6 kg	1.5 kg	800 g	330 g

8 in. diameter sieves, No. 8 to No. 200 shall not exceed 200g / sieve

12 in. diameter sieves, No. 8 to No. 200 shall not exceed 469g / sieve

TOTAL WEIGHT 5942.1 g						
SIEVE SIZE	LONG GRAD. WEIGHT RET.		WEIGHT RETAINED	WEIGHT PASSING	PERCENT PASSING	PERCENT REQUIRED
2 1/2 in.			g	g	%	%
2 in.			g	g	%	%
1 1/2 in.			g	g	%	%
1 in.			0 g	5942.1 g	%	%
3/4 in.			690.6 g	g	%	%
1/2 in.			2462.7 g	g	%	%
3/8 in.	P F		1368.1 g	g	%	%
No. 4	g		997.0 g	g	%	%
No. 6	g		g	g	%	%
No. 8	g		264.5 g	g	%	%
No. 16	g		g	g	%	%
No. 30	g		g	g	%	%
No. 50	g		g	g	%	%
No. 100	g		g	g	%	%
No. 200	g		g	g	%	%
PAN	g		88.1 g	g	%	%
DECANT	ORIGINAL		FINAL	GRAMS LOSS	PERCENT LOSS	PERCENT REQUIRED
	5942.1 g		5885.2 g	56.9 g	1.0 %	%

4) The weight passing each sieve is calculated next by subtracting the weight retained on the largest sieve from the total sample weight. The weight retained on the next largest sieve is subtracted from the weight of material still remaining from the first subtraction. The process is continued for all sieves.

1 in.	5942.1 – 690.6	= 5251.5
3/4 in.	5251.5 – 2462.7	= 2788.8
3/8 in.	2788.8 – 1368.1	= 1420.7
No. 4	1420.7 – 997.0	= 423.7
No. 8	423.7 – 264.5	= 159.2
Pan material		= 88.1

TOTAL WEIGHT 5942.1 g					
SIEVE SIZE	**LONG GRAD. WEIGHT RET.**	**WEIGHT RETAINED**	**WEIGHT PASSING**	**PERCENT PASSING**	**PERCENT REQUIRED**
2 1/2 in.		g	g	%	%
2 in.		g	g	%	%
1 1/2 in.		g	g	%	%
1 in.		0 g	5942.1 g	%	%
3/4 in.		690.6 g	5251.5 g	%	%
1/2 in.		2462.7 g	2788.8 g	%	%
3/8 in.	P F	1368.1 g	1420.7 g	%	%
No. 4	G	997.0 g	423.7 g	%	%
No. 6	G	g	g	%	%
No. 8	g	264.5 g	159.2 g	%	%
No. 16	g	g	g	%	%
No. 30	g	g	g	%	%
No. 50	g	g	g	%	%
No. 100	g	g	g	%	%
No. 200	g	g	g	%	%
PAN	g	88.1 g	g	%	%
DECANT	**ORIGINAL**	**FINAL**	**GRAMS LOSS**	**PERCENT LOSS**	**PERCENT REQUIRED**
	5942.1 g	5885.2 g	56.9 g	1.0 %	%

5) The percent passing is calculated for each sieve by using the following formula:

$$\% \text{ Passing} = \frac{\text{Weight passing each sieve}}{\text{Original dry sample weight}} \times 100$$

Example:

3/4 in. $\frac{5251.5}{5942.1} \times 100 = 88.4\%$

1/2 in. $\frac{2788.8}{5942.1} \times 100 = 46.9\%$ etc.

TOTAL WEIGHT 5942.1 g						
SIEVE SIZE	**LONG GRAD. WEIGHT RET.**		**WEIGHT RETAINED**	**WEIGHT PASSING**	**PERCENT PASSING**	**PERCENT REQUIRED**
2 1/2 in.			g	g	%	%
2 in.			g	g	%	%
1 1/2 in.			g	g	%	%
1 in.			0 g	5942.1 g	100 %	%
3/4 in.			690.6 g	5251.5 g	88.4 %	%
1/2 in.			2462.7 g	2788.8 g	46.9 %	%
3/8 in.	P F		1368.1 g	1420.7 g	23.9 %	%
No. 4	g		997.0 g	423.7 g	7.1 %	%
No. 6	g		g	g	%	%
No. 8	g		264.5 g	159.2 g	2.7 %	%
No. 16	g		g	g	%	%
No. 30	g		g	g	%	%
No. 50	g		g	g	%	%
No. 100	g		g	g	%	%
No. 200	g		g	g	%	%
PAN	g		88.1 g	g	%	%
DECANT	**ORIGINAL**		**FINAL**	**GRAMS LOSS**	**PERCENT LOSS**	**PERCENT REQUIRED**
	5942.1 g		5885.2 g	56.9 g	1.0 %	%

6) If the test has been done accurately, the sum of all the fractional weights retained (including the material in the pan) and the weight of material removed by decantation will be approximately equal to the original dry weight. If the two weights differ by more than 0.3 percent, based on the original dry sample weight, the results are considered invalid.

$$\frac{\text{Original Dry weight - Summation Weights Measured}}{\text{Original Dry Weight}} \times 100$$

Example:

$$\frac{5942.1 - (690.6 + 2462.7 + 1368.1 + 997.0 + 264.5 + 89.1 + 56.9)}{5942.1} \times 100 =$$

0.2% = valid test

NOTE: This is a check on the workmanship and does not have to be performed every time. Occasionally perform this calculation to be assured that the proper testing technique is being used.

Fineness Modulus

The fineness modulus is related to gradation. This term is commonly associated with aggregates for portland cement concrete. The purpose is to determine the relative coarseness or fineness of the aggregate grading.

The fineness modulus is computed in accordance with **AASHTO T 27** by adding the cumulative percentages retained on the 3 1/2 in., 2 1/2 in., 2 in., 1 1/2 in., 3/4 in., 3/8 in., No. 4, No. 8, No. 16, No. 30, and No. 100 sieves, and then dividing by 100. A large number means a coarse material. A small number means a fine material.

Sieve Size	100	-	% Passing	=	% Retained
3/8 in.	100	-	100	=	0.0
No. 4	100	-	100	=	0.0
No. 8	100	-	89.2	=	10.8
No. 16	100	-	68.3	=	31.7
No. 30	100	-	45.1	=	54.9
No. 50	100	-	13.8	=	86.2
No. 100	100	-	2.6	=	97.4
					281.0

281.0 / 100 = 2.81 = Fineness Modulus

Sieve Analysis for Dense Graded (Long Graded) Materials

Dense graded materials, such as compacted aggregates and some B borrows or subbase, consist of substantial quantities of material retained on and passing the No. 4 sieve.

The procedure for performing a sieve analysis on a dense graded material is:

1) The entire sample is sieved and weighed in the same manner as well-graded materials, except the smallest sieve must be the No. 4 sieve.

2) The portion of the sample passing the No. 4 sieve is weighed.

3) Using a sand sample splitter, the portion of the sample passing the No. 4 sieve is reduced to approximately 500 grams.

4) The reduced sample is weighed and a proportionate factor is determined by dividing the weight of the portion of the sample passing the No. 4 sieve by the weight of the reduced sample.

   For example: If the total weight of the portion of material passing the No. 4 sieve is 2221.4 grams and the reduced sample weight is 503.4 grams, the proportionate factor would be equal to 2221.4 grams divided by 503.4 grams, which equals 4.413.

5) The reduced sample is sieved for 15 minutes.

6) The material on each sieve is weighed and multiplied by the proportionate factor. The calculated weight is recorded as the total weight of material retained on that sieve.

7) The calculations for percentage passing are completed as for well-graded aggregates.

An example, using the proportionate factor for all minus No. 4 sieve material, is shown below:

TOTAL WEIGHT	**6800.8 g**					
SIEVE SIZE	**LONG GRAD. WEIGHT RET.**		**WEIGHT RETAINED**	**WEIGHT PASSING**	**PERCENT PASSING**	**PERCENT REQUIRED**
1 1/2 in.			**0 g**	**6800.8 g**	**100 %**	**100 %**
1 in.			**312.9 g**	**6487.9 g**	**95.4 %**	**80-100 %**
3/4 in.			**877.2 g**	**5610.7 g**	**82.5 %**	**70-90 %**
1/2 in.			**1228.3 g**	**4382.4 g**	**64.4 %**	**55-80 %**
3/8 in.	**P F**	**4.234**	**580.5 g**	**3801.9 g**	**55.9 %**	**%**
No. 4	**g**		**1072.1 g**	**2729.8 g**	**40.1 %**	**35-60 %**
No. 6	**g**		**g**	**g**	**%**	**%**
No. 8	**222.1 g**		**940.4 g**	**1789.4 g**	**26.3 %**	**25-50 %**
No. 16	**g**		**g**	**g**	**%**	**%**
No. 30	**192.7 g**		**815.9 g**	**973.5 g**	**14.3 %**	**12-30 %**
No. 50	**g**		**g**	**g**	**%**	**%**
No. 100	**g**		**g**	**g**	**%**	**%**
No. 200	**84.8 g**		**359.0 g**	**614.5 g**	**9.0 %**	**5.0-10.0 %**
PAN	**4.2 g**		**17.8 g**	**g**	**%**	**%**
DECANT	**ORIGINAL**		**FINAL**	**GRAMS LOSS**	**PERCENT LOSS**	**PERCENT REQUIRED**
	6800.8 g		**6220.7 g**	**580.1 g**	**8.5 %**	**%**
DENSE GRADED MATERIAL			**TOT. WEIGHT PASS No. 4**	**SAMPLE SIZE**	**PROPORT. FACTOR**	
			2133.2 g	**503.8 g**	**4.234**	

DELETERIOUS MATERIALS

Most of the tests for deleterious materials apply to coarse aggregates. The only concern in fine aggregates is organic impurities.

Deleterious Materials in Coarse Materials

These tests are based on visual inspection and require training and judgment. Deleterious substances of concern are clay lumps and friable particles, non-durable materials, coke, iron, and chert. Coke and iron are only of concern in slag, and no guidelines are given.

Clay Lumps And Friable Particles

These particles are defined as the material remaining after decantation that can be mashed with the fingers. The test is performed according to **AASHTO T 112**.

A sample of material is made up from material retained on the No. 4 sieve and above, following decantation of sieve analysis. The sample is soaked 24 hours, plus or minus 4 hours, in distilled water. After soaking, any material or particles that can be broken by the fingers and are removable by wet sieving are classified as clay lumps or friable material. The material retained after wet sieving is dried to constant weight and weighed.

The percent clay or friable material is calculated by:

$$\%\ \text{Clay or Friable} = \frac{\text{Dry Weight of Sample} - \text{Dry Weight Ret. (Wet Sieving)}}{\text{Dry Weight of Sample}} \times 100$$

Non-Durable Materials

Non-durable materials are divided into two types:

1) Soft material as determined by **ITM 206**; and

2) Structurally weak material as determined by visual inspection.

Both tests are performed on all the sample material retained on the 3/8 in. sieve and above.

The Scratch Hardness Test applies only to gravel coarse aggregate. Each particle which is to be tested is subjected to a scratching motion of a brass rod, using a 2 lbf load. Particles are considered soft if a groove is made in them without deposition of metal from the brass rod or if separate particles are detached from the rock mass. A particle is classified as soft only if one-third or more of its volume is found to be soft.

Structurally weak materials are visually identified and include:

1) Ocher -- soft rock clay to sand particles cemented with iron oxide which ranges in color from tan through yellows, reds, and browns.

2) Unfossilized shells.

3) Conglomerates -- cemented gravels.

4) Shale -- laminated rock of clay-size minerals.

5) Limonite -- iron oxide, ranging from yellow-brown to black in color that is frequently a concretion around a soft core.

6) Weathered schist.

7) Coal, wood, and other foreign materials.

8) Materials with loosely cemented grains and/or a weathered coating.

9) Soft sandstone.

Particles determined to be soft or structurally weak are combined, and the percent by mass of non-durable material is calculated by:

$$\% \text{ Non-durable} = \frac{\text{Weight of Non-Durable Material above 3/8 in. Sieve}}{\text{Weight of Sample Above the 3/8 in. Sieve}} \times 100$$

Chert

Chert is visually picked from coarse aggregates. It is a rock of varied color, composed of glassy silica, and very fine-grained quartz. Unweathered chert appears hard, dense, and brittle with a greasy texture. Weathered chert appears chalky and dull. Chert is likely to have concave surfaces with sharp outer edges when freshly broken.

Total chert is picked from the sample following decantation and gradation. Chert is picked from all the material retained on the 3/8 in. sieve and above for aggregate sizes 2 through 8, 43, 53, and 73, and from all material retained on the No. 4 sieve and above for aggregate sizes 9, 11, 12, and 91. The procedure for determining the total chert includes:

1) All chert, including questionable chert, is picked from the sample.

2) All pieces of questionable chert is further tested by:

   a) Since all chert will scratch glass, the particle ability to scratch glass is checked.

   b) The particles are broken with a hammer to differentiate between soft or non-durable material, and chert. Chert breaks into rounded surfaces with sharp edges. If rocks are found to be soft and non-durable, they are added to the soft or non-durable material.

3) All material determined to be chert is weighed and the percent of total chert is calculated using the formulas below:

For aggregate sizes 2 through 8, 43, 53, and73:

$$\% \text{ Total Chert} = \frac{\text{Weight of Chert above the 3/8 in. Sieve}}{\text{Total Weight of Sample above the 3/8 in. Sieve}} \times 100$$

For aggregate sizes 9, 11, 12, and 91:

$$\% \text{ Total Chert} = \frac{\text{Weight of Chert above the No. 4 Sieve}}{\text{Total Weight of Sample above the No. 4 Sieve}} \times 100$$

Deleterious Materials in Natural Sands

The purpose of the **AASHTO T 21** test is to furnish a warning that further tests on the sand are necessary before the sands are approved for use. The procedure is:

1) A glass bottle is filled with approximately 4 1/2 fl oz of the sand to be tested.

2) A 3 percent sodium hydroxide ($NaOH$) solution in water is added until the volume of the sand and liquid, indicated after shaking, is approximately 7 fl oz.

3) The bottle is stoppered, shaken vigorously, and allowed to stand for 24 hours.

4) The color of the supernatant liquid above the test sample is compared to reference standard colors.

5) If the color of the supernatant liquid is darker than that of the referenced color, the sand may contain injurious organic compounds, and further tests are to be made before approving the sand for use in concrete

The **AASHTO T 71** test compares the compressive strength of mortar specimens made from the suspect sand to the compressive strength of mortar made from acceptable sand.

The colorimetric test (**AASHTO T 21**) is conducted first. If the color in solution is lighter than a standard, the fine aggregate is acceptable. If the color is darker, further testing of the fine aggregate for strength in mortar, **AASHTO T 71**, is required. If the effect of any organic matter reduces the strength no more than 5 percent, the fine aggregate is acceptable. Also, observations should be made to determine whether the organic material retards the mortar set or changes the necessary air-entraining admixture dosage.

CRUSHED PARTICLES

ASTM D 5821 outlines the procedure for determining the quantity of crushed particles. Crushed particle requirements are used for gravel coarse aggregates in HMA (one and two-faced), compacted aggregates, and asphalt seal coats (except seal coats used on shoulders).

The test is conducted on all particles retained on the No. 4 sieve and is performed as follows:

1) The total sample is washed over the No. 4 sieve and dried to a constant weight.

2) Each particle is evaluated to verify that the crushed criteria is met. If the fractured face constitutes at least one-quarter of the maximum cross-sectional area of the rock particle and the face has sharp or slightly blunt edges, it is considered a crushed particle.

3) Particles are separated into two categories: (a) crushed particles, and (b) non-crushed particles.

4) When two-faced crushed particles are required for aggregates used in HMA the procedure is repeated on the same sample.

5) The percent of crushed particles is then determined by the following formula:

$$P = \frac{F}{F + N} \times 100$$

where:

P = percentage of crushed particles
F = weight of crushed particles
N = weight of uncrushed particles

FLAT AND ELONGATED PARTICLES

ASTM D 4791 outlines the procedure for determining the quantity of flat and elongated particles. The Standard Specifications define a flat and elongated particle as “one having a ratio of length to thickness greater than five.

The test is conducted on all particles retained on the 3/8 in. sieve and each sieve above the 3/8 in. sieve and is performed as follows:

1) The total sample retained on the 3/8 in. sieve is weighed.

2) Each size fraction above the 3/8 in. sieve present in the amount of 10% or more of the original sample is reduced until approximately 100 particles are obtained for each size fraction.

3) Each particle is measured with the proportionate caliper device (Figure 4.1) set at the required ratio.

4) The flat and elongated particles are weighed for each sieve.

5) The percent of the flat and elongated particles is then determined on each sieve by the following formula:

$$\%\ \text{Flat and Elong. Particles} = \frac{\text{Weight of F \&E Particles for each Sieve}}{\text{Total Weight of Reduced Sample for each Sieve}} \times 100$$

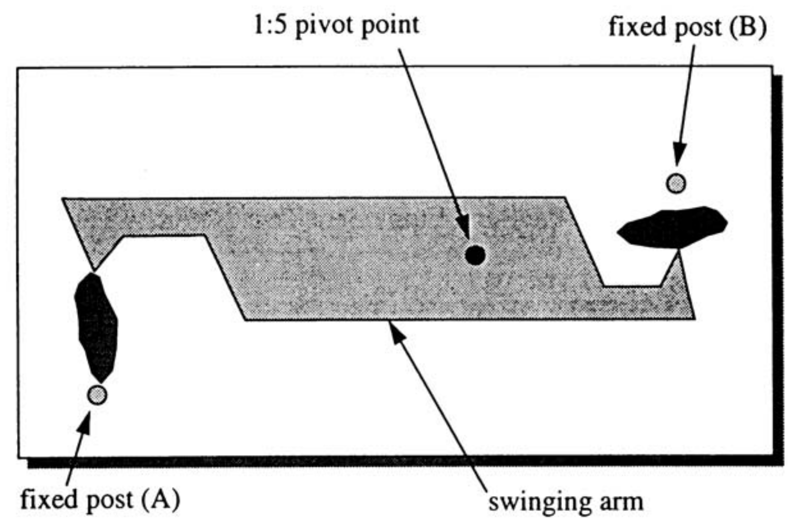


Figure 4.1 - Proportional Caliper Device to Measure Flat and Elongated Particles

CLAY CONTENT

Clay content is the percent of clay material contained in the aggregate fraction that is finer than a No. 4 sieve. The test used for determining the clay content is the Sand Equivalent Test (**AASHTO T 176**). In this test, a sample of fine aggregate is placed in a graduated cylinder with a flocculating solution and agitated to loosen clayey fines present in and coating the aggregate. The flocculating solution forces the clayey material into suspension above the granular aggregate. After a period that allows sedimentation, the cylinder height of suspended clay and sedimented sand is measured (Figure 4.2). The sand equivalent value is computed as a ratio of the sand to clay height readings expressed as a percentage.

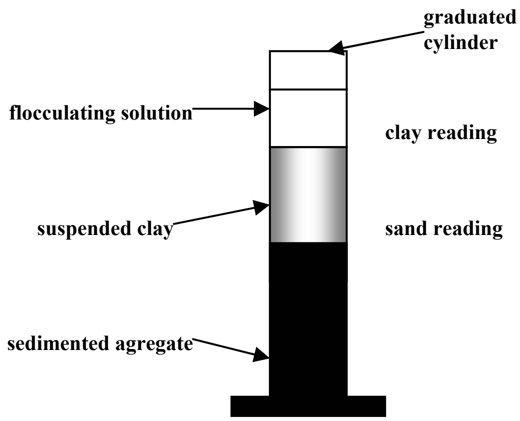


Figure 4.2 Sand Equivalent Test

FINE AGGREGATE ANGULARITY

Fine aggregate angularity is the percent air voids present in loosely compacted aggregates finer than the No. 8 sieve. The test used for determining the Fine Aggregate Angularity is the Uncompacted Void Content of Fine Aggregate Test (**AASHTO TP 33 - Method A**). In the test, a sample of fine aggregate is poured into a small calibrated cylinder by flowing through a standard funnel (Figure 4.3). By determining the mass of the fine aggregate (W) in the filled cylinder of known volume (V), void content can be calculated as the difference between the cylinder volume and fine aggregate volume collected in the cylinder. The fine aggregate bulk specific gravity (G_{sb}) is used to compute the fine aggregate volume.

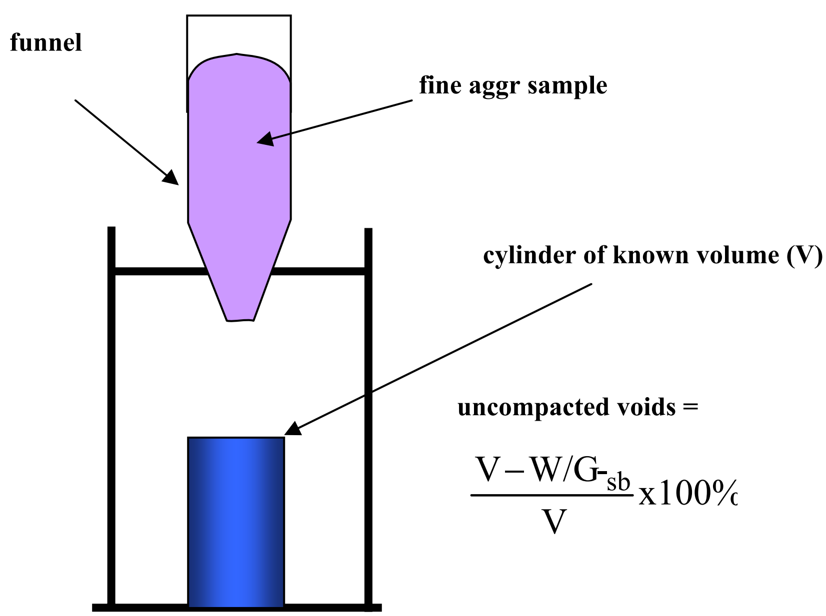


Figure 4.3 Fine Aggregate Angularity Apparatus

PLASTIC LIMIT

Compacted aggregate materials, coarse aggregate sizes 43, 53, and 73, require tests for determining the plastic limit and liquid limit of minus No. 40 sieve material. The plastic limit can be performed accurately only in a laboratory; however, the possibility of a plastic condition may be determined by a field check test. The liquid limit must be performed in the laboratory.

The plastic limit test **cannot** be performed on the same sample used for any other field tests. Therefore, in addition to the sample selected for the other field tests, the technician should split and dry a sample of approximately 1000 grams. The test is performed using a small spatula, a ground-glass plate, and an evaporating dish. The procedure for the test is:

1) Using sufficient sieves, remove all the material above the No. 40 sieve. It is important to have all of the minus No. 40 sieve material in the sample. Any minus No. 40 sieve material clinging to the larger particles should be scraped free and all the dried composite particles retained above the No. 40 sieve should be broken up.

2) Thoroughly mix the minus No. 40 sieve material and select a sample of about 20 grams.

3) Place the sample in a suitable container, preferably an evaporating dish, and thoroughly mix with distilled or demineralized water until the material becomes plastic enough to be easily shaped into a ball.

4) Take about half of the sample and squeeze and form it into the shape of a small cigar. Place the specimen on a ground glass plate. With fingers, using just sufficient pressure, roll the specimen into a thread of uniform diameter throughout its length. The rate of rolling will be between 80 and 90 strokes per minute, counting a stroke as a complete motion of the hand forward and back to the starting position. The rolling will continue until the thread is 1/8 in. in diameter.

Most of the compacted aggregate materials do not contain plastic fines. If the specimen cannot be rolled into a thread of 1/8 in. diameter, the technician may assume that the material is either nonplastic or has a low plastic content, and no additional testing is needed. If the specimen can be rolled into a thread of 1/8 in., the material is considered plastic and further testing should be done for an accurate determination of plasticity index.

SURFACE MOISTURE TESTS

When aggregates are used in portland cement concrete mixtures, the surface moisture on the aggregates must be determined to adjust aggregate masses for moisture content and to determine the surface moisture contribution to the mixing water.

When a moisture content is desired, the sample must be reduced to test size and the test run as quickly as possible after the sample has been taken. Any delay in running the test after the sample has been selected may allow the material to lose moisture and cause inaccurate results.

The test procedure is:

1) Weigh the sample before drying and record the weight.

2) Dry the sample and allow to cool to room temperature.

3) Weigh the sample and record the weight.

4) Determine the moisture percent using this formula:

$$\% \text{ Moisture} = \frac{\text{Weight Wet} - \text{Weight Dry}}{\text{Weight Dry}} \times 100$$